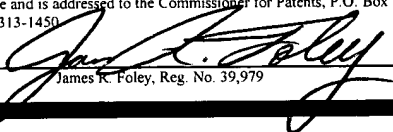


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**PATENT**

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 James R. Foley, Reg. No. 39,979	

**MULTI-LAYER STAGGERED POWER BUS LAYOUT DESIGN**

**Inventors**

Matthew Russell  
13924 W. Preserve Blvd.  
Burnsville, MN 55337

Dushyant Narayen  
718 Inverness Way  
Sunnyvale CA 94087

Dongyi Zhou  
1371 Thunderbird Ave.  
Sunnyvale, CA 94087

## **Background of the Invention**

The present invention generally relates to the design of buses used to carry power and/or ground in semiconductor design or manufacturing, and more specifically relates to a multi-layered staggered power bus layout design.

As semiconductors become smaller, the input/output area is impacted. Although it is often desired to design a smaller input/output area, in order to maintain current carrying capabilities, the strips forming the power and ground buses must meet a minimum width requirement. The number of strips need for each power and ground bus is determined by the maximum metal width. A metal utilization upper limit determines how compact the buses can be placed within the layout. These limitations present two difficulties for the input/output bus layout. The metal utilization limit determines the extent to which the input/output can be reduced while the maximum metal width determines the current each strip of metal can carry.

Current methods used to resolve the metal utilization problem include using a single layer of metal or using multiple layers of metal. If only one layer of metal is used, generally the input/output occupies a large area on the silicon. When multiple layers of metal are used, identical geometries are generally used on adjacent metal layers so that the input/output area can be reduced due to the fact that the power/ground current are carried by multiple layers of metal.

Problems occur when using these methods to resolve the maximum metal width and metal utilization problems. For example, current bottle necks occur in traditional wire bond, pad on I/O wire bond, and flip chip bond, therefore, electronic migration becomes an issue. In addition, tools need to be developed to account for different bonding schemes and to ensure each strip of the metal bus carries a certain amount of current. Currently, these tools are not available.

### **Objects and Summary**

An object of an embodiment of the present invention is to reduce the I/O area on the silicon.

Another object of an embodiment of the present invention is to provide multiple buses on a metal layer which are not electrically connected to each other.

Yet another object of an embodiment of the present invention to provide buses on a plurality of metal layers in which the buses on one metal layer have a different geometry than the buses on another metal layer.

A further object of an embodiment of the present invention is to reduce the occurrence of current bottlenecks.

Briefly, and in accordance with at least one of the foregoing objects, an embodiment of the present invention provides a multiple layer but layout design which consists of multiple metal layers with buses of different geometries. Although the buses on each layer are not connected to each other, a plurality of vias are provided between the metal layers to electrically connect the buses on each layer to each other.

### **Brief Description of the Drawings**

The present invention and the advantages thereof will become more apparent upon consideration of the following detailed description when taken in conjunction with the accompanying drawing, wherein like reference numerals represent like elements and wherein FIGURE 1 is a cross sectional view of a multiple layer bus layout design which is in accordance with an embodiment of the present invention.

## **Description**

While the invention may be susceptible to embodiment in different forms, there is shown in the drawing, and herein will be described in detail a specific embodiment with the understanding that the present disclosure is to be considered an exemplification of the principles of the invention, and is not intended to limit the invention to that as illustrated and described herein.

A portion of an integrated circuit 10 (i.e., a multiple layer bus layout design) in accordance with an embodiment of the present invention is shown in FIGURE 1. The design is configured to reduce the I/O layer on the silicon and provide multiple buses on a metal layer which are not electrically connected to each other. The design provides buses on multiple layers, where the buses have different geometries. The design is also configured to reduce the occurrence of bottlenecks.

The integrated circuit 10, includes a first metal layer 12, a second metal layer 14, and an insulative layer 16 disposed between the first and second metal layers. Buses 18, 20 are provided on the first metal layer 12, however, buses 18, 20 are not conductively connected to each other on the first metal layer 12. Buses 22, 24 are provided on the second metal layer 14, however, buses 22, 24 are not conductively connected to each other on the second metal layer 14. Buses 18, 20 are staggered with respect to buses 22, 24 such that a portion of bus 18 overlaps a portion of bus 22 and a portion of bus 24. A portion of bus 20 also overlaps a portion of bus 24.

Vias 26a, 26b, 26c extend between the first metal layer 12 and the second metal layer 14. Via 26a extends between bus 18 on the first metal layer 12 and bus 22 on the second metal layer 14. Via 26b extends between bus 18 on the first metal layer 12 and bus 24 on the second metal layer 14. Via 26c extends between bus 20 on the first metal layer 12 and bus 24 on the second metal layer 24. By arranging the busses 18, 20, 22, 24 in this staggered manner, buses 18, 20, on the first metal layer 12 are electrically connected through bus 24 on the second metal layer 14 and buses 22, 24 on the second metal layer 14 are electrically connected through bus 18 on the first metal layer 12. Thus, although the

buses 18, 20 on the first metal layer 12 are not connected together through the first metal layer 12, the current can freely pass through the vias 26a, 26b, 26c from bus 18 to bus 24 on the second metal layer 14 and return through the vias 26a, 26b, 26c to bus 20 on the first metal layer 12. The staggered design, therefore, resolves the conflict amongst a large current carrying capability requirement, upper limit for metal utilization, maximum metal width and limited I/O area.

The bus layout design of the present invention provides several advantages. The bus configuration shown in FIGURE 1 can be used with all existing bonding schemes. No new software tool is needed to make designs to comply with metal utilization limits, metal width limit and electron migration limit. The buses on the adjacent metal layers are connected by vias in the overlapping area across the entire input/output width. Metals on the same layer can be placed closer together without violating metal utilization requirements due to the lack of metal interconnection on the same layer. As a result, therefore, input/output area requirement on the silicon is smaller. Thus, a smaller input/output area can be achieved without violating metal utilization, metal width and electron migration rules.

While an embodiment of the present invention is shown and described, it is envisioned that those skilled in the art may devise various modifications of the present invention without departing from the spirit and scope of the appended claims. For example, although only two metal layers are shown in FIGURE 1, additional metal layers can be used if desired, and depending on the application.